PRODUCTION ENGINEERING MEASURES
Crystal Unit CR-(XM-46)/U

SECOND QUARTERLY REPORT
November 1962 to February 1963

Production Engineering Measure (PEM) in accordance with Step I of Signal Corps Industrial Preparedness Procurement Requirement. (SCIPPR) No. 15, dated 1, October 1958 for Overtone Filter Crystal Units, 30 - 60 MC/s, CR-(XM-46)/U Per Specification SCS-135 dated 20 February 1962.

Contract #DA-36-039-SC-86737

Order #19059-PP-62-81-81

E.B. LEWIS CO., INCORPORATED
East Hartford, Conn.

Prepared by	Approved by	Approved by
Robert P. McComb	Ernest B. Lewis	Charles G. Robb
Robert P. McComb	Ernest B. Lewis	Charles G. Robb

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SECOND QUARTERLY REPORT

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CR-(XM-46)/U

Purpose:

The purpose of this study is to design and carry out the production engineering necessary for the manufacture of quartz crystals for filter applications operating on the third overtone in the frequency range of 30 to 60 MC/s in accordance with Signal Corps Specification SCS-135 dated 20 February 1962.

It is also the purpose of this program to carry out Step I of the Production Engineering Measures as specified in Signal Corps Industrial Preparedness Procurement Requirements #15 dated 1 October 1958.

ABSTRACT

Improved design data for AT Cut Quartz Crystals for filter application, operating on the third overtone at 30 MC/s is given.

Details of final lapping and polishing operation are outlined as are the plating techniques for all aluminum electrode unit.

A comparison of electrical parameters is given.

NARRATIVE

As was reported in the First Quarterly Report, the two major problems that arose were unsuitable surface conditions and unacceptable electrode plating.

A rigorous investigation of the lapping and polishing procedures was undertaken as the first objective.

The majority of all crystals fabricated by E. B. Lewis Co., Inc. prior to any work concerned with this contract did not involve extensive polishing technique.

All lapping operations were performed on P.R. Hoffman Model PR-1 Planetary Lapps. The polishing was done on two VanConey Lapps. The extent of the polish was more in the way of a finish lapping operation using American Optical #309 polishing compound, with a particle size of one to three microns. It was noticed that in the attempt to achieve a finer finish using the American Optical #309, the resistance of the crystal units was improved to a point. However, as the degree of polish was increased, the resistance of the crystals suddenly increased to a point where they would be unacceptable.

It was soon realized that the crystals required on this contract would require a much finer finish, further in the higher frequency range it would be necessary to control the losses due to breakage when lapping the very thin plates.

Equally important would be the control of flatness and frequency spread. For these reasons it became necessary to use the Phelper Model 12FF Planetary Lapp or the P. R. Hoffman PR-4. For polishing the VanConey Lapps are satisfactory with the exception of a speed increase from 750 RPM to 1200 RPM.

Finish Lapping Operation:

For crystals operating on the third overtone at 30 MC/s, the fundamental frequency is 10 MC/s. Twenty-four .312 diameter blanks in six carriers comprise the load. The blanks are 8425. ±25 KC/s out of intermediate lapping. Intermediate lapping is done in a PR-1 using Carborundum Company KO Abrasive with a grain size of 11 microns.

The crystals are then lapped using American Optical M305 Abrasive and a radio receiver to monitor frequency. At 10 MC/s the frequency spread is approximately 10 KC/s. Present procedures require that the lapping plates be corrected when the frequency spread approaches 20 KC/s.

The Pre-Polish frequency is determined in such a way that for two minutes of polish they will be well within the Pre-Plate frequency tolerance.

Polishing Operation:

The crystals are run in the VanConey Lapping Machine for two minutes. The polishing compound used is composed of white rouge, distilled water, tri-sodium phosphate and a wetting agent.

The frequency after polishing is 10,035 KC/s ±10 KC/s. Prior to base plating the crystals are frequency calibrated and sorted into groups where the maximum spread is ±2.5 KC/s.

The problem of a suitable electrode plating was next investigated.

An evaluation was made on the basis of the first crystals fabricated. It would appear at this time that an all aluminum electrode will be necessary.

The first difficulty encountered was an inconsistancy in the amount of plate back obtained using both a tungsten filament in the Constantin Model 3 and our own National Research Model CO Base Plater using molybdenum boats.

It was found that an amalgamation occurred between the aluminum and tungsten which caused less aluminum to be evaporated on the crystals with each successive plating operation, and finally a complete deterioration of the filament.

This has been overcome by the construction of a specially formed filament which is essentially helical in shape and made up of five turns of tungsten wire consisting of three strands approximately .030 inches in diameter. This filament configuration has proved to be the most durable to date, and is shown in Figure 1.

Special cylindrical chambers were made up for use with the Model 3 Constantin Plater to facilitate the mounting of the masks. A glass plate is used as a cover to allow observation of the firing. We are planning to introduce a resistance measuring device so that uniform conductivity with each successive firing can be obtained.

A further problem which has developed with the use of aluminum is the loss of conductivity between the spring contact and the plated electrode both before and after beading, but much more severe after beading. We believe this is due to an oxide formed on the surface of the aluminum electrode. At present the crystals are immediately mounted into the holders after base plating and cement beads applied to the springs. The cement used is DuPont #5504 and is baked at 135° C for a period of 1-1/2 to 2 hours. This procedure solved the problem of conductivity loss, however it was noted that on further investigation it was found that loss of conductivity was not as serious as first anticipated if the crystals were processed immediately after base plating and stored at 132° C.

Final frequency adjustment is made by etching the electrode with a .5% solution of NAOH. The etching time required for final frequency adjustment is determined primarily by the strength of the etching solution and the amount of base plate previously applied. At present, satisfactory results are obtained using the .5% NAOH solution on crystals that are 30 to 10 KC/s below the "Finished" or "Final" frequency.

The next procedure was to determine the optimum electrode diameter which would permit us to meet the parameters specified in the SOS-135 Specification. The procedure is based on previous work done by Dr. Rudolph Bechmann of the United States Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey.

A new electrode diameter was decided upon and a new mask ordered, however, it was not available in time for evaluation in this report. But one of our production masks with the proper diameter electrode and a slightly different tab design was used successfully. The design of this electrode as well as the new one are shown in Figures 2 and 3.

Crystals fabricated with the new electrode diameter were designated SC-1307. X-Y Plots of two of these crystals mounted on Z,Z' and X,X' respectively are shown in Figures 4 and 5.

Table I presents a comparison of the parameters for the SC-1430 and SC-1307 units with the maximum values obtained from the SCS-135 Specification.

The assembly of the SC-1307 is shown in Figures 6 and 7 for crystal units mounted on Z,Z' and X,X' respectively.

TABLE I

SC-1430	SC-1307	SCS-135
fo= 30 MC/s	fo= 30 MC/s	fo= 30 MC/s
Co= .989 pf	Co= 1.22 pf	Co= 1.5 pf
R= 250 ohms	R= 80.7 ohms	R= 100 ohms
df= 95 cps	df= 211 cps	df= 200 cps
C_1= 1.33 x 10^{-4} pf	C_1= 3.89 x 10^{-4} pf	C_1= 3 x 10^{-4} pf
r= 7439	r= 3154	r= 5000
Q= 158 x 10^3	Q= 169 x 10^3	Q= 179 x 10^3
L= 209 mhy	L= 72.3 mhy	L= 93.4 mhy

Conclusions:

It is evident that the requirements of the SCS-135 Specification with regard to unwanted modes and electrical parameters can be met for the 30 MC/s frequency range.

The techniques that we are now using for final lapping and polishing will be adequate for production in quantity of the CR-(XM-46)/U crystal in the 30 MC/s frequency range.

It will be necessary, however, to work out a more efficient method of aluminum plating so that the frequency spread after base plating is held to a much closer tolerance to facilitate a more rapid rate of production in final frequency finishing.

Program for the Next Interval:

In the immediate future we will process a sufficiently large lot of crystals at the 30 MC/s frequency; from this lot samples for submission to USASRDL will be selected. The remainder of the units will be evaluated and a statistical analysis made to determine where any problems might arise in production.

Initial work on the design of the 45 MC/s units will be started during this time.

Conferences:

During the interval covered by this report, the following conferences were held.

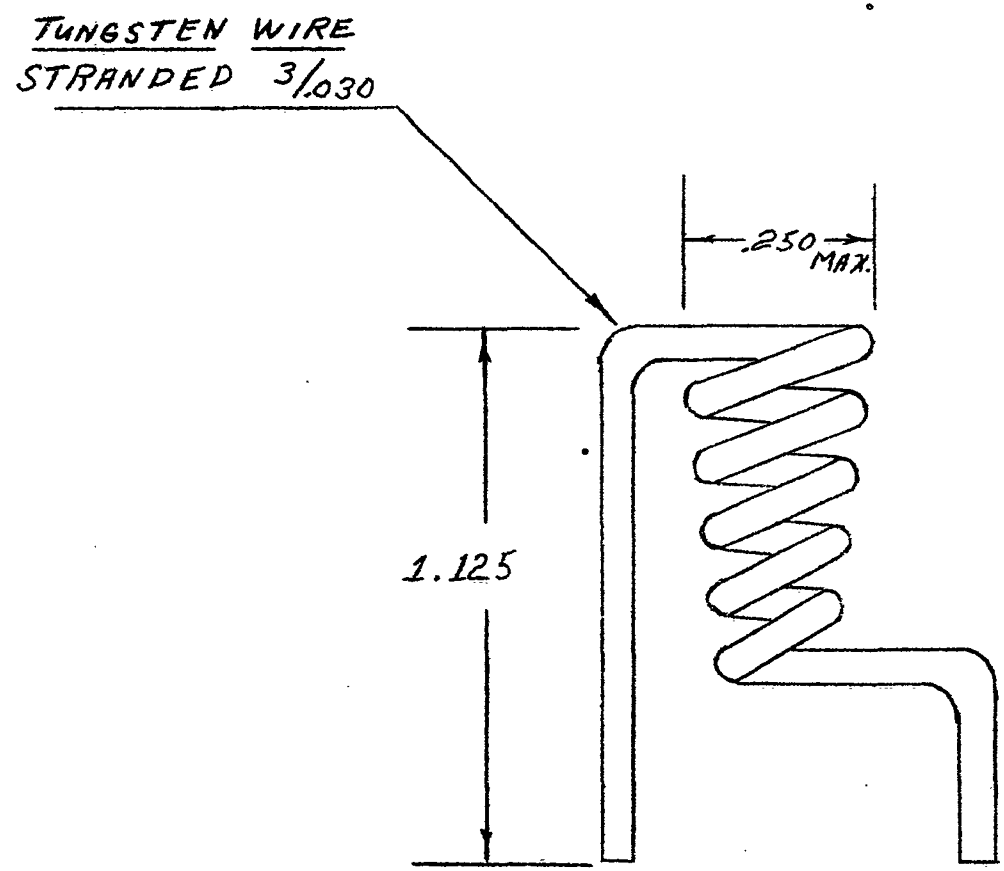
26, 27 and 28 November 1962, Mr. Albert E. Schlick, Property Manager, U. S. Army Electronics Materiel Agency, visited our plant for the purpose of assisting us in the completion of the DD1342 forms and outlining the contractors responsibility concerning the administration and accountability for government owned property.

3 January 1963, Mr. H.J. Barrett, Industrial Equipment Specialist, U. S. Army Electronics Materiel Agency, Industrial Equipment Division, visited our plant for the purpose of accepting for the government the final three items under Schedule "A" Facilities that were acquired for the account of the government.

23 and 24 January 1963, Mr. Santo Tutino, Auditor, Bridgeport Area Office, U. S. Army Audit Agency visited our plant for the purpose of audit.

MAN HOURS

Ernest B. Lewis	20.0
Robert P. McComb	224.5
Crystal Fabrication	39.6
TOTAL MAN HOURS	284.1



FILAMENT CONSTRUCTION
FOR
BASE PLATING

FIGURE 1

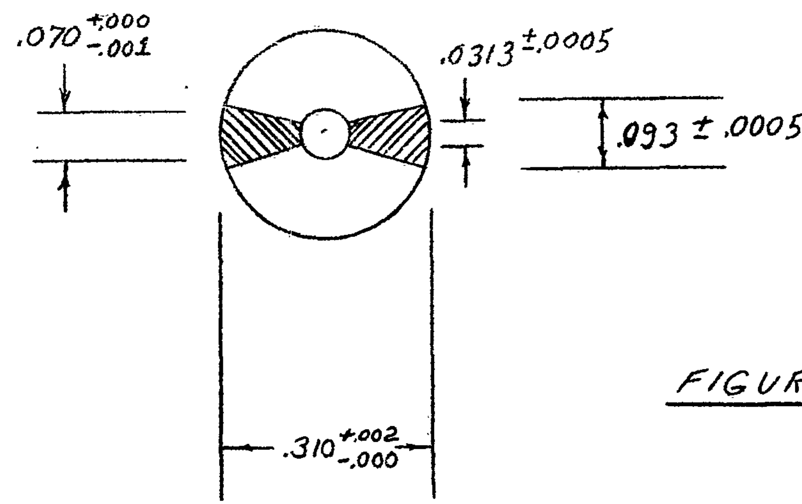


FIGURE 2

PLATING CONFIGURATION
USING DOVETAIL
LEAD-OFF

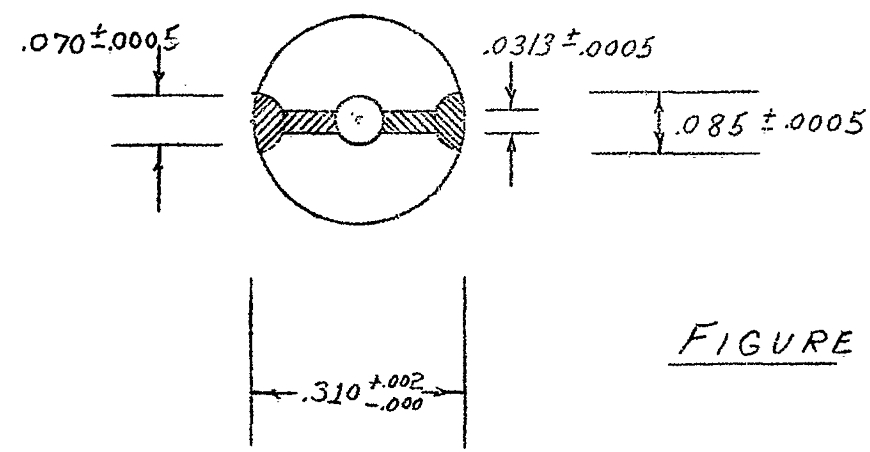


FIGURE 3

PLATING CONFIGURATION
USED ON SC-1307
CRYSTAL UNITS

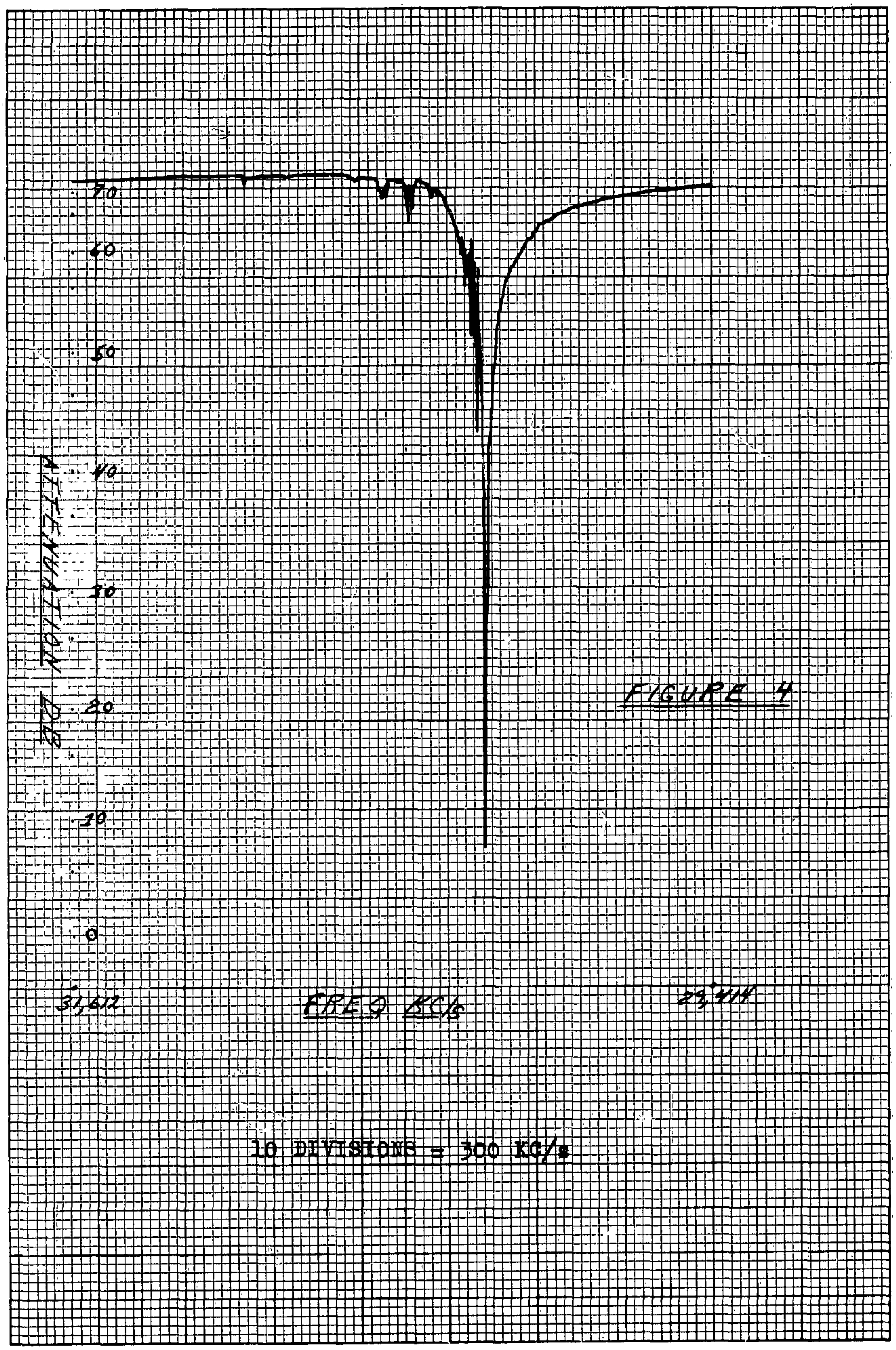

ATTENUATION DB
70
60
50
40
30
20
10
0
31,612
FREQ KC/S
29,414
10 DIVISIONS = 300 KC/s

FIGURE 4

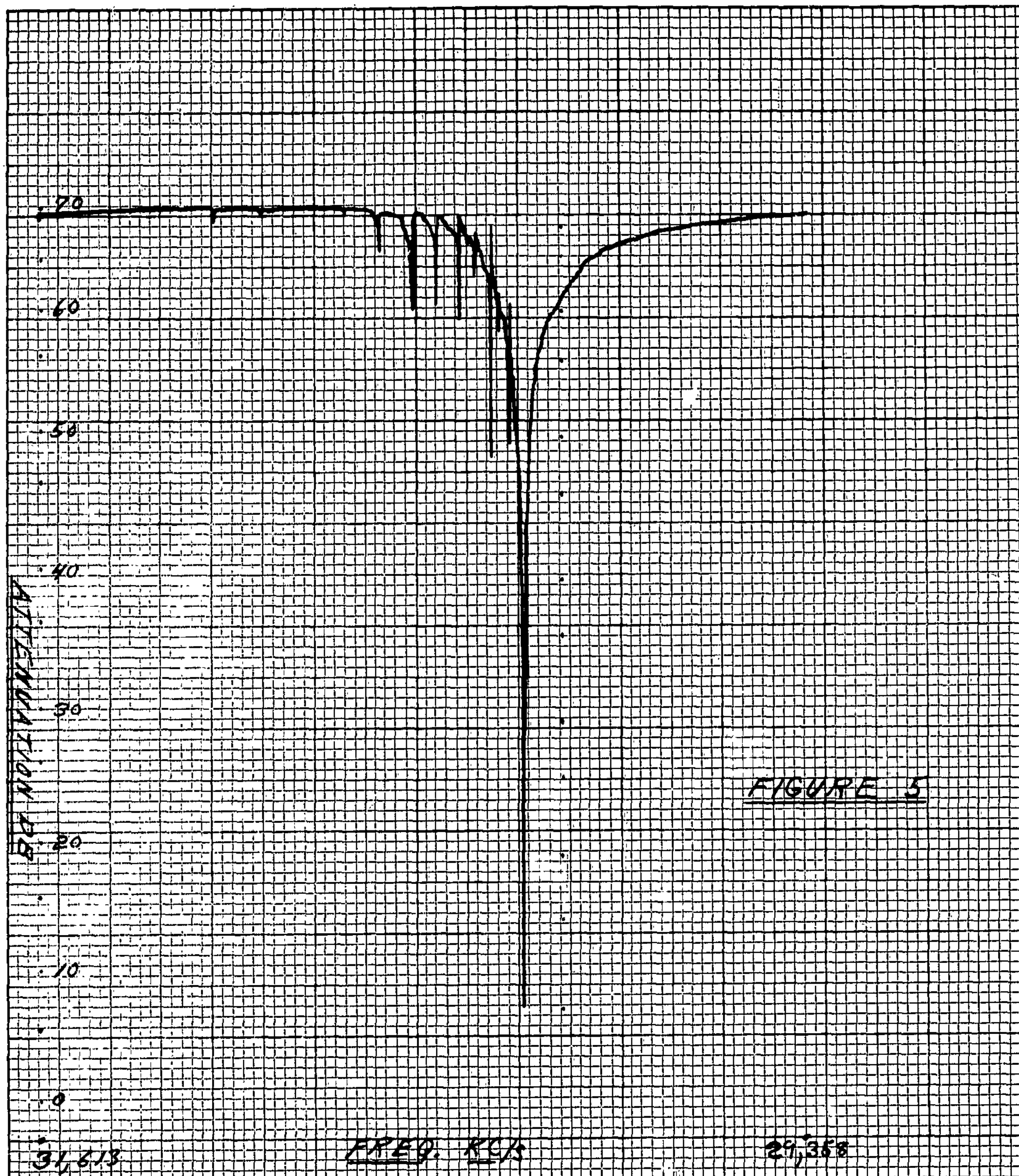


FIGURE 5

10 DIVISIONS = 300 KC/s

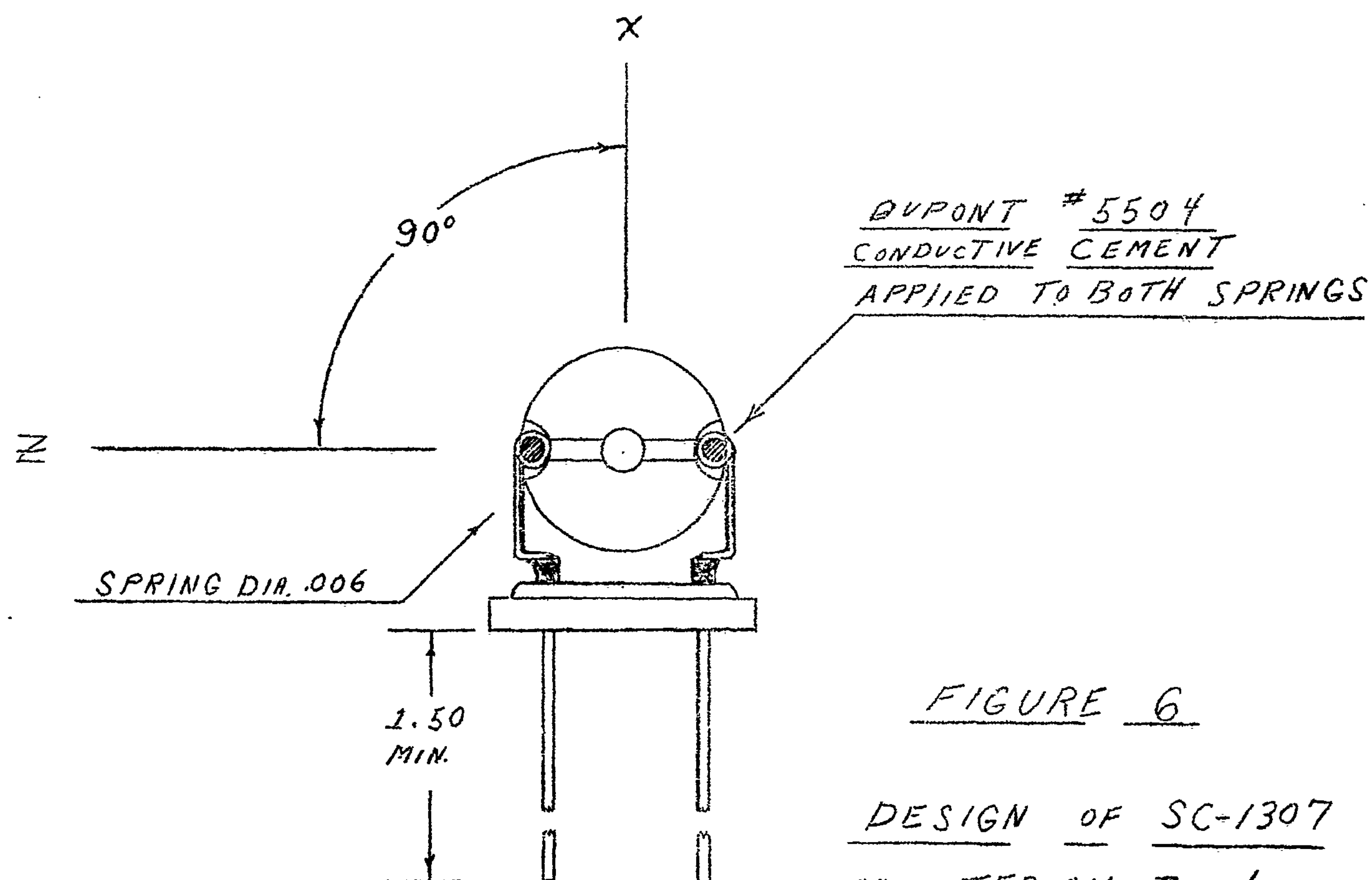


FIGURE 6

DESIGN OF SC-1307

MOUNTED ON Z-Z'

HOLDER: HC-18/U

MEL SMITH Co.

PART No. B11180-3

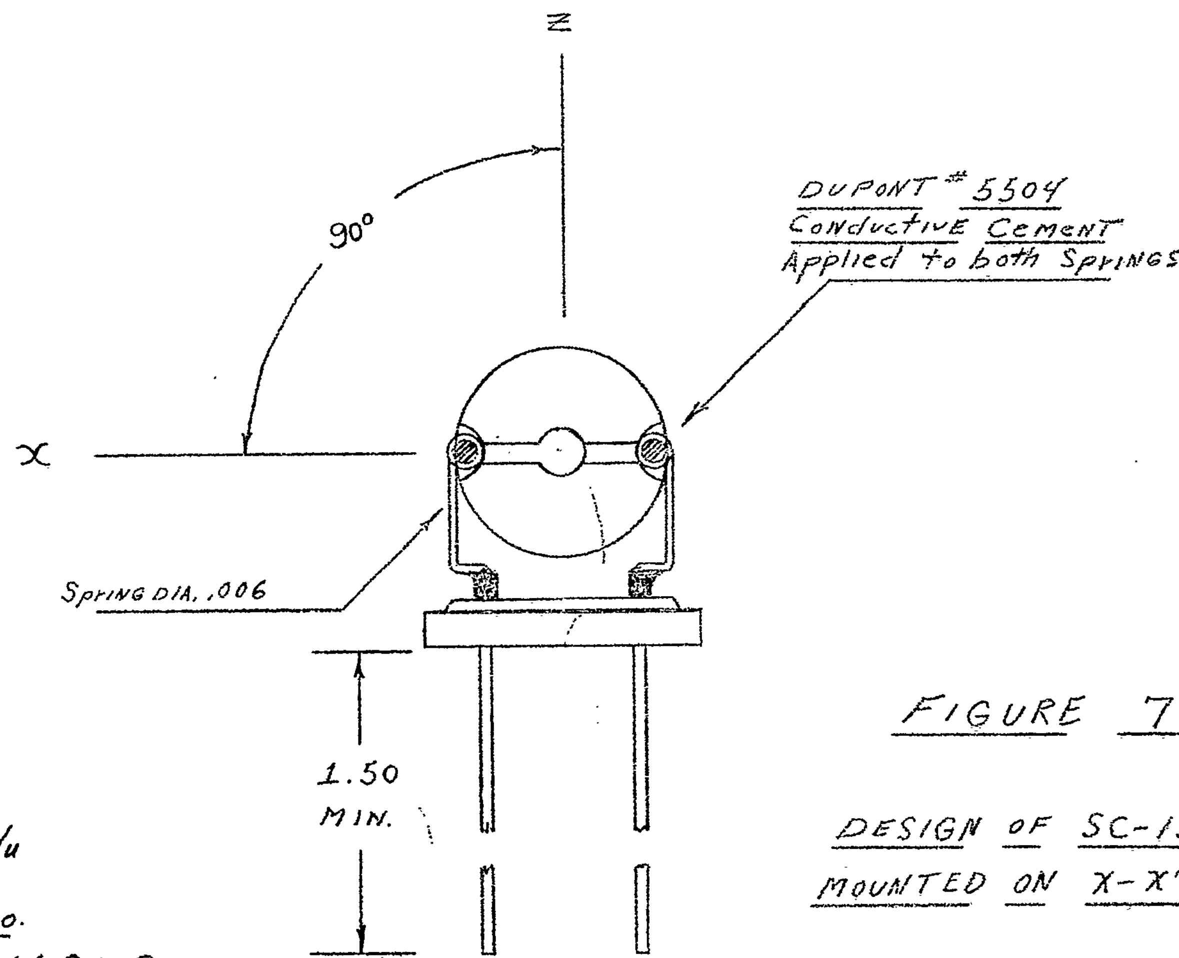


FIGURE 7

DESIGN OF SC-1307
MOUNTED ON X-X'

Holder: HC-18/u

MEL SMITH Co.
PART NO. B11180-3

E. B. LEWIS CO., INC. EAST HARTFORD, CONN.

FOR

SHIP TO

USAEMA
PHILADELPHIA, PENNA

PROMISED DELIVERY DATE
Jan 15, 1963

S. O. EL 6843-B

CONT# DA-36-039-SC-86737
ORDER# 19059-PP-62-81-81

P.O. ________

DESCRIPTION:

DATE Dec 27, 1962

ITEMS 1-1-1
ENGINEERING SAMPLES
15 Ea. @ 30.000 MC/S
Natural Quartz

How Shipped ________

Process 50 pieces
HC-18/U

SC-1

	SCHEDULED FOR:
Cutting 35° 27' ± 2'	
Squaring .310 $^{+.002}_{-.000}$ dia 1/16" flat Parallel ZZ'	
Lapping Flat and Parallel to one Light Band 2 Min. Polish	
Preplate freq. + 60 KC/s Pre-polish freq = Δf 60 KC/s / 2 min Out of Intermediate Lapp 8425 ± 25 KC/s	
Plating .064 dia. tabs on ZZ' .064 dia tabs on XX' .075 dia tabs on ZZ'	
Finishing .075 dia tabs on XX' Oscillator Correlation TS683 1 MW drive 100 ohms MAX Load Cap. 20 pf ± 2%	
Testing MIL-C-3098/C SCS-135	
Shipping	

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APPENDIX I

Formulae for Crystal Parameters

(1) $$C_1 = \frac{Co}{r}$$

(2) $$r = \frac{Co\ (Fs)}{2\ df\ (Co + C_L)}$$

(3) $$Q = \frac{1}{w\ C_1\ R}$$

(4) $$L = \frac{XL}{w}$$

Where:

C_1 = Motional Capacitance

Co = Static Capacitance to one decimal place

C_L = Load Capacitance in pf (20.0)

r = Ratio of Static Capacitance to Motional Capacitance

df = Difference in frequency (in CPS) between Series Resonance and Anti Resonance at 20.0 pf when measured in Crystal Impedance Meter TS-683/TSM

Fs = Measured Series Resonant frequency of the crystal unit in CPS

R = Equivalent resistance of the crystal unit at Series Resonance.

$w = 2\pi\ Fs$